REPORT 40

SWEEP

SOIL AND WATER ENVIRONMENTAL ENHANCEMENT PROGRAM

PAMPA

PROGRAMME D'AMELIORATION DU MILIEU PEDOLOGIQUE ET AQUATIQUE

Canada

Ontario

SWEEP

is a $30 million federal-provincial agreement, announced May 8, 1986, designed to improve soil and water quality in southwestern Ontario over the next five years.

PURPOSES

There are two interrelated purposes to the program; first, to reduce phosphorus loadings in the Lake Erie basin from cropland run-off; and second, to improve the productivity of southwestern Ontario agriculture by reducing or arresting soil erosion that contributes to water pollution.

BACKGROUND

The Canada-U.S. Great Lakes Water Quality Agreement called for phosphorus reductions in the Lake Erie basin of 2000 tonnes per year. SWEEP is part of the Canadian agreement, calling for reductions of 300 tonnes per year — 200 from croplands and 100 from industrial and municipal sources.

PAMPA

est une entente fédérale-provinciale de 30 millions de dollars, annoncée le 8 mai 1986, et destinée à améliorer la qualité du sol et de l'eau dans le Sud-ouest de l'Ontario.

SES BUTS

Les deux buts de PAMPA sont: en premier lieu de réduire de 200 tonnes par an d'ici 1990 le déversement dans le lac Erie de phosphore provenant des terres agricoles, et de maintenir ou d'accroître la productivité agricole du Sud-ouest de l'Ontario, en réduisant ou en empêchant l'érosion et la dégradation du sol.

SES GRANDES LIGNES

L'entente entre le Canada et les États-Unis sur la qualité de l'eau des Grands Lacs prévoyait de réduire de 2 000 tonnes par an la pollution due au phosphore dans le bassin du lac Erie. PAMPA fait partie de cette entente qui réduira cette pollution de 300 tonnes par an — 200 tonnes provenant des terres agricoles et 100 tonnes provenant de sources industrielles et municipales.

TECHNOLOGY EVALUATION AND DEVELOPMENT SUB-PROGRAM

MANAGEMENT OF MULCH TILLAGE SYSTEMS ON CLAY SOILS

FINAL REPORT

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EXECUTIVE SUMMARY

Field experiments were conducted at Lucan (silt loam soil) and at Comber (clay loam soil) in 1991 to evaluate mulch tillage system effects on soil properties and corn growth and yield. At each location two experimemtal sites were established; one following a previous crop of grain corn and one following soybeans.

The aim of this study was to provide specific recommendations for various mulch tillage systems in regards to the effect of soil moisture content at the time of fall tillage and on the timing of spring secondary tillage within a mulch system. In addition, various tillage equipment was assesed for its impact on soil properties and corn growth following previous crops of corn and soybeans.

Measurements were taken on soil roughness, residue cover, soil moisture, aggregate size distribution, penetrometer resistance and corn growth and yield.

Soil physical properties and crop response were not affected by soil moisture contents at the time of fall tillage when the range between "wet" and "dry" conditions was 2-5% (gravimetric soil moisture). No particular mulch implement appeared to be less suited than others to working in wetter soil conditions.

Harrowing or levelling operations in the fall following chisel plowing and performing secondary tillage earlier in the spring may effectively reduce soil drying rates. However, those practices will probably have a noticeable impact on seedbed conditions only in springs where there are significant and prolonged early spring drying trends.

In general, mulch tillage systems were more suited to corn production in terms of soil conditions and corn yield when soybeans rather than corn was the previous crop. However, following soybeans, nearly all mulch tillage systems reduced residue cover to levels where significant protection from soil erosion will not be provided. Our recommendations based

on this study would be to perform no fall tillage operations following soybeans and to limit tillage in the spring to a minimum.

Following corn, most mulch tillage operations provided adequate soil residue cover but, produce soil physical conditions (coarser seedbeds, greater soil strengths) inferior to those obtained by moldboard plowing. Generally this did not result in lower corn yields on the silt loam soil but on the clay loam soil mulch systems tended to result in corn yields lower than those obtained by moldboard tillage.

This study was conducted over a single season which included some extreme weather conditions and therefore caution should be exercised in drawing conclusions from this data.

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INTRODUCTION

The adoption of various conservation tillage systems by Ontario farmers has increased steadily in recent years. The use of mulch tillage systems based principally on some form of chisel plowing or offset discing in the fall has expanded most rapidly. Although adoption has been relatively rapid, further understanding of management techniques for these systems is required.

The aim of this study was to provide specific recommendations in regards to, 1) the effect of soil moisture content at the time of fall primary mulch tillage, 2) the timing of spring secondary tillage within a mulch system and 3) the interaction of the two previously mentioned factors with various tillage implements, ground engaging tools and depths of operation.

MATERIALS AND METHODS

Background

Experimental sites were established in the fall of 1990 at Lucan (Huron silt loam; 13% sand, 67% silt, 20% clay) and at Comber (Brookston clay loam; 29% sand, 42% silt, 29% clay). Experimental layouts were repeated on two separate areas at each site, one where soybeans had been grown and the other where grain corn had been grown in 1990. Each experiment consisted of 14 treatments which were arranged in a randomized complete block design with four replications.

Experimental Treatments

The following is a list of tillage treatments as imposed on all four experiments:

1) No fall tillage; spring cultivate only
2) Moldboard tillage - wet

3) Moldboard tillage - dry

4) Offset disc - wet

5) Offset disc - dry

6) Chisel plow, sweep teeth - wet

7) Chisel plow, sweep teeth - dry

8) Chisel plow, twisted shovel, 12 cm deep - wet

9) Chisel plow, twisted shovel, 12 cm deep - dry

10) Chisel plow, twisted shovel, 18 cm deep - wet

11) Chisel plow, twisted shovel, 18 cm deep - dry

12) Chisel plow, twisted shovel, 18 cm deep - dry - early secondary tillage

13) Chisel plow, twisted shovel, 18 cm deep - dry - levelling harrow

14) Chisel plow, twisted shovel, 18 cm deep - dry - levelling harrow, early secondary tillage.

In the above treatments 'wet' and 'dry' refer to relative soil moisture conditions at the time of fall tilllage. Early secondary tiilage refers to a single pass with the field cultivator two weeks prior to corn planting. All other secondary tillage was performed at the time of planting.

Measurements

Soil Roughness and Surface Residue

Immediately following tillage operations in the fall soil roughness and residue measurements were made on selected treatments. A portable relief meter was used to measure the vertical displacement of the soil profile at 5 cm intervals. Two transects of 20 points each were taken in each plot and residue cover was determined at the same time by counting the number of sliding plexiglass rods on the relief meter that touched previous crop residue.

Residue cover was measured in the spring on all plots using a nylon rope with 50 markings placed diagonally across the plot and counting the number of marks which lay directly over residue. Two determinations were made on each plot.

Soil moisture

Volumetric soil moisture was determined using the Time Domain Reflectometry (TDR) method (Topp et al., 1984). 15 cm stainless steel probes were inserted horizontal to, and 5 cm below the soil surface to measure soil moisture contents during the early spring. In addition, 15 cm and 20 cm probes were inserted vertically into the soil to measure moisture content in the plow layer.

Soil Aggregate Size

Immediately following corn planting soil samples for aggregate size distribution were taken from the row area with a rectangular sampler that removes a 300 cm^2 block of soil to depth of 7 cm. Two samples per plot were taken. Soil samples were dried in forced air ovens at 30° C and passed through a nest of sieves on a vibratory shaker to obtain the following size fractions: 1) >10 mm 2) 5-10 mm 3) 2-5 mm 4) 1-2 mm 5) 0.5-1 mm and 6) <0.5.

Penetrometer Resistance

Penetrometer resistance was determined using a Rimik hand-held recording penetrometer. Penetrometer insertions were made in the mid-row position but never in a tractor wheel track. Insertions were made to a depth of 20 cm. A minimum of 5 insertions were made on each plot. Soil moisture measurements were taken at the time of penetrometer resistance to assure that soil moisture differences were not obscuring treatment effects.

Corn Growth and Yields

Corn dry matter accumulation was determined by whole plant harvest of 12-15 plants per plot. Final grain corn yields were determined by hand harvesting 10 m of row from each plot. These cobs were then shelled using a small thresher followed by determinations of grain

weight and moisture.

Statistical Analysis

All plot measurements were analyzed using accepted analysis of variance procedures. Treatments were determined to be different by using a protected Least Significant Difference (LSD) at the 5% probability level. Tables within this report containing treatment means which are not different ($P=0.05$) are identified at the bottom of the column with the letters NS.

RESULTS AND DISCUSSION

Moisture Contents

The aim of the experiment was to perform each of the fall tillage operations at both relatively wet and relatively dry soil conditions. Soil samples were taken at each tillage event to calculate gravimetric soil moisture content. These values are presented in Table 1 and illustrate the difficulty, which farmers often face, in obtaining dry soil conditions when heavy crop residues remain on the field in the fall. Differences between wet and dry soil moistures ranged from 1.9 to 5.2 percentage points. This modest range of moisture content difference was enough to cause easily discernible differences in tractor and implement performance while tillage operations were being performed.

Table 1. Gravimetric soil moisture contents at time of fall tillage in the 0-10 cm depth interval.

Area	Comber				Lucan			
Previous crop	Corn		Soybeans		Corn		Soybeans	
Soil moisture	wet	dry	wet	dry	wet	dry	wet	dry
% moisture	30.4	27.5	27.8	22.6	30.4	28.5	28.0	25.6

Soil Roughness and Surface Residue

These measurements are recorded in Tables 2 and 3 for the Comber and Lucan sites respectively.

Results from these measurements were generally as expected with treatments providing a wide variety of soil roughness and residue combinations. At each site the levelling harrow significantly reduced the soil roughness compared to the unharrowed chisel plow treatment without significantly altering the residue cover. The unharrowed chisel plow treatment (18 cm deep) resulted in the highest roughness value at all sites, although this value was not always significantly higher than the moldboard or chisel plow (12 cm deep) treatments.

When corn was the previous crop, offset discing and chisel plowing with sweeps tended to leave more surface residue than chisel plowing with twisted shovel teeth. After soybeans, all mulch tillage systems left similar levels of surface residue. At the Comber site, significant soil protection (> 20% residue cover) after soybeans was achieved only from the no fall tillage option.

Table 2. The effect of various fall tillage systems on surface roughness and residue cover on a Brookston clay loam soil.

Previous crop: Grain corn

Tillage system	Roughness* (mean displacement, cm)	Residue (surface cover, %)
No fall tillage	1.32 c*	83.8 a
Offset disc	3.06 b	62.5 b
Chisel, sweeps	3.48 b	55.6 bc
Chisel, shovels, 12 cm	3.94 b	50.0 bc
Chisel, shovels, 18 cm	5.11 a	41.9 c
Chisel, shovels, 18 cm (+ levelling harrow)	3.78 b	53.1 bc
Moldboard plow	5.44 a	10.6 d

Previous crop: Soybeans

Tillage system	Roughness* (mean displacement, cm)	Residue (surface cover, %)
No fall tillage	0.60 d	81.3 a
Offset disc	2.40 c	16.9 b
Chisel, sweeps	2.58 c	15.0 b
Chisel, shovels, 12 cm	3.69 ab	16.3 b
Chisel, shovels, 18 cm	4.25 a	12.5 b
Chisel, shovels, 18 cm (+ levelling harrow)	2.81 c	18.1 b
Moldboard plow	2.99 bc	9.4 b

Roughness was measured using a portable relief meter. Values represent the mean vertical displacement from the average soil level.

* Tillage treatments followed by the same letter are not significantly different (P=0.05).

Table 3. The effect of various fall tillage systems on surface roughness and residue cover on a Huron silt loam soil immediately after tillage operation.

Previous Crop: Grain Corn

Tillage System	Roughness* (mean displacement, cm)	Residue (surface cover, %)
No fall tillage	1.35* d	81.3 a
Offset disc	2.19 c	52.5 b
Chisel, sweep	2.17 c	50.0 bc
Chisel, shovels, 12 cm	3.59 ab	37.5 cd
Chisel, shovels, 18 cm	3.91 a	29.5 d
Chisel, shovels, 18 cm (+ levelling harrow)	2.98 b	34.4 d
Moldboard plow	3.60 ab	5.0 e

Previous Crop: Soybeans

Tillage System	Roughness* (mean displacement, cm)	Residue (surface cover, %)
No fall tillage	1.68 d	71.9 a
Offset disc	2.51 b	26.9 b
Chisel, sweep	2.22 cd	40.6 b
Chisel, shovels, 12 cm	3.04 bc	36.9 b
Chisel, shovels, 18 cm	3.80 a	26.9 b
Chisel, shovels, 18 cm (+ levelling harrow)	2.69 bc	29.4 b
Moldboard plow	2.80 bc	0.6 c

* Roughness was measured using a portable relief meter. Values represent the mean vertical displacement from the average soil level.
* Tillage treatments followed by the same letter are not significantly different (P=0.05).

In the spring of 1991, following secondary tillage and planting operations, surface residue measurements indicated that following corn, at both locations, differences were only significant between moldboard tillage and all other systems (data not shown). Following soybeans, there were no significant differences among any tillage systems at Comber and all values were less than 20%. At Lucan, although differences were statistically significant, all values were less

than 12% surface cover.

Our results indicate that mulch tillage systems employed following corn leave an adequate amount of surface residue for erosion protection, however, following soybeans even limiting tillage to two (spring) passes with a field cultivator can reduce surface residue levels to less than 20%.

Soil Moisture Levels

Having established treatments in the previous fall with various levels of soil surface cover and roughness our aim in the spring of 1991 was to monitor the effect of these conditions on soil moisture levels. Unfortunately, rainfall throughout the month of April was well above normal at both Comber and Lucan and drying trends were not observed. Table 4, however, serves to illustrate that the use of the levelling harrow did tend to conserve soil moisture both following corn and soybeans at both locations when measured on one date in April, these differences however were not significant. Had dry weather conditions prevailed earlier in the month it is apparent that the unlevelled chisel plow treatment may have dried out considerably more than in the case where harrows were used.

Table 4. The effect of various fall tillage systems on soil moisture at 5 cm depth in April.

Tillage System	Location: Previous Crop:	Comber* Corn	Comber* Soys	Lucan Corn	Lucan Soys
		—— soil moisture m^3/m^3 ——			
Chisel plow, shovels		.198	.209	.129	.144
Chisel plow, shovels (+ levelling harrow)		.229	.220	.159	.176
LSD (0.05)		NS	NS	NS	NS

* Sampling dates for Comber and Lucan, were April 17 and 25 respectively.

Table 5 outlines soil moisture data from Comber and points to the fact that while harrowing in the fall tended to increase surface moisture contents, an early spring cultivation caused a greater impact on soil moisture status. A field cultivation on April 29 resulted in significantly higher soil moisture content at the 5 cm depth on May 3 or May 10 than on chisel plowed treatments that were not cultivated. However, after all treatments were cultivated and corn was planted there were no significant differences in surface soil moisture contents.

Table 5. The effect of various tillage systems on soil moisture at 5 cm depth. Location is Comber where previous crop was corn.

Tillage System	Date:*	April 17	May 3	May 10	May 13
		—— soil moisture m^3/m^3 ——			
Moldboard		-	-	-	.225
Cultivate only		-	-	-	.280
Chisel, shovels, no harrow		.198	.174	.173	.287
Chisel, shovels, no harrow (+ early secondary)		-	.252	.248	.291
Chisel, shovels, levelling harrow		.229	.209	.202	.277
Chisel, shovels, levelling harrow (+ early secondary)		-	.256	.273	.263
LSD (P=0.05)		NS	.048	.048	NS

* Early secondary tillage occurred April 29 on selected plots, secondary tillage on all plots and corn planting occurred May 11.

Our results indicate that both management practices (fall harrowing and early secondary tillage) had the potential to reduce drying of the soil surface on chisel plowed plots. However, drying intensity and duration was not significant enough in 1991 to cause any real difference in seedbed conditions at time of planting.

Soil Aggregate Size

Soil samples were taken from all plots following planting to determine the effect of tillage systems on the size of seedbed aggregates. There was no effect of soil moisture content at the time of fall tillage on aggregate size distribution in the following spring. Table 6 presents aggregate data for 6 tillage systems at all experimental sites. At both Comber and Lucan the percentage of fine soil aggregates (less than 5 mm in diameter) in the seedbed following grain corn was significantly higher for moldboard than for any of the mulch tillage systems. After soybeans, however, moldboard plowing did not result in significantly finer aggregation, in fact, there were no differences among any of the tillage systems in terms of aggregate size distribution.

These results would collaborate with those of (Vyn, 1987) and indicate that in terms of seedbed fineness, reduced tillage systems are more likely to result in seedbed conditions similar to those with conventional tillage following soybeans than if corn was grown in the previous year.

Table 6. The effect of various tillage systems on proportion of soil aggregates less than 5 mm.

Tillage System	Location: Previous Crop:	Comber* Corn	Comber* Soys	Lucan Corn	Lucan Soys
		%	%	%	%
Spring cultivate only		21.3 b*	31.8 a	41.7 b	45.6 a
Moldboard (dry)		38.9 a	38.6 a	64.3 a	49.7 a
Offset disc (dry)		24.5 b	39.9 a	43.9 b	44.6 a
Chisel, sweeps (dry)		24.9 b	42.1 a	49.7 b	44.2 a
Chisel, shovels, 12 cm (dry)		21.5 b	38.7 a	43.4 b	45.3 a
Chisel, shovels, 18 cm (dry)		25.4 b	35.9 a	48.5 b	43.6 a

* Tillage treatments values within a column are not significantly different (P=0.05) when followed by the same letter.

Penetrometer Resistance

Soil strength measurements were determined using a hand-held penetrometer at all sites during the month of June. Values for penetrometer resistance (kPa) are recorded for two soil depth intervals on Tables 7 and 8. On the silt loam soil at Lucan there was no significant difference in penetrometer resistance among any of the tillage treatments at the 6-9 cm depth interval when soybeans were the previous crop (see Table 7). At this experimental site, in the 15-18 cm depth interval, moldboard plow and the chisel plow (shovel, 18 cm deep) treatments tended to have significantly lower penetrometer resistances than the other tillage treatments.

At Lucan, when the previous crop was corn, moldboard plow treatments had significantly lower penetrometer resistances than all treatments except for chisel plowing (18 cm deep, shovels) and offset discing (wet) in the 6-9 cm depth interval. In the 15-18 cm depth interval at this same site, differences in penetrometer resistance were significant, and although not all treatments were distinct from each other, the ranking in descending order was: spring cultivate only, offset disc, chisel plow (12 cm deep, shovels) chisel plow (18 cm deep, shovels), chisel plow (sweeps) and fall moldboard plow.

At Lucan, there were no significant differences in penetrometer resistance between wet and dry soil conditions at the time of primary tillage.

At the Comber site, where soybeans were the previous crop, moldboard plow treatments tended to have lower penetrometer resistance values than the mulch systems in the 6-9 cm depth interval, but were significantly lower only compared to spring cultivate only and chisel plow (12 cm deep, shovels). At the 15-18 cm depth interval, however, the moldboard treatments had significantly lower penetrometer resistance than all other tillage systems.

Table 7. The effect of tillage systems on penetrometer resistance in the plow layer of a Huron silt loam soil, June 3, 1991.

Tillage System	Previous Crop: Depth:	Corn 6-9 cm	Corn 15-18 cm	Soys 6-9 cm	Soys 15-18 cm
		kPa			
Spring cultivate only		939	1280	618	972
Offset disc (wet)		877	1267	536	992
Offset disc (dry)		992	1332	586	1073
Chisel, sweep (wet)		975	973	610	987
Chisel, sweep (dry)		989	998	569	864
Chisel, shovel, 12 cm (wet)		1040	1267	642	960
Chisel, shovel, 12 cm (dry)		972	1242	568	963
Chisel, shovel, 18 cm (wet)		807	1150	702	914
Chisel, shovel, 18 cm (dry)		883	1062	489	815
Moldboard (wet)		764	897	560	648
Moldboard (dry)		688	744	444	619
LSD (0.05)		206	230	NS	196
Average (wet)		893	1111	610	900
Average (dry)		905	1076	531	867

At Comber, following grain corn, at the 6-9 cm depth interval, the distinction between moldboard plowing penetrometer resistance and all other treatments was greater than following soybeans (see Table 8). Here, penetrometer resistance following moldboard plowing was significantly lower than nearly all other treatments. At the 15-18 cm depth interval the trend continued, as moldboard had significantly lower penetrometer resistance than all other treatments, and there were no significant differences among these other treatments.

Again, at the Comber sites there were no significant differences in terms of penetrometer resistance among any of the wet soil - dry soil comparisons.

Table 8. The effect of various tillage systems on penetrometer resistance in the plow layer of a Brookston clay soil, June 7, 1991.

Tillage System	Previous Crop: Depth:	Corn 6-9 cm	Corn 15-18 cm	Soys 6-9 cm	Soys 15-18 cm
		——— kPa ———			
Spring cultivate only		1026	781	1530	1177
Offset disc (wet)		1081	780	1337	1066
Offset disc (dry)		1047	793	1413	1123
Chisel, sweep (wet)		1130	769	1200	946
Chisel, sweep (dry)		1086	779	1380	1017
Chisel, shovel, 12 cm (wet)		1122	861	1652	1122
Chisel, shovel, 12 cm (dry)		1153	758	1640	1142
Chisel, shovel, 18 cm (wet)		1090	787	1297	1079
Chisel, shovel, 18 cm (dry)		1168	755	1212	1009
Moldboard (wet)		706	539	1157	740
Moldboard (dry)		822	458	960	615
LSD (0.05)		234	134	292	173
Average wet		1026	747	1328	991
Average dry		1055	709	1321	981

In general, the tendency for mulch tillage systems to result in greater soil strength (penetrometer resistance) and, therefore, perhaps greater resistance to root elongation, compared to conventional moldboard tillage increased as soil clay content increased and if corn rather than soybeans was the previous crop. Differences in soil moisture contents of 2-5% at the time of fall tillage did not have an effect on soil strength in general in the following spring, nor did it appear to be particularly problematic for a specific mulch tillage implement.

Corn Growth and Yields

In the spring of 1991 growing conditions following planting were good and although detailed emergence notes were not taken, no significant delays or emergence problems were observed at either Comber or Lucan.

At the end of May the Comber site received very heavy rainfall (more than 15 cm). Due to the low infiltration rates at this site ponding occurred which severely retarded corn growth and caused much variability. Because of this it was decided to delay the dry matter harvest until the plants had time to recover and compensate. Unfortunately, there was no further rainfall at this site until mid-August and corn growth was very poor and variable throughout the summer. Plant harvests were, therefore, never taken at Comber. At Lucan, growing conditions were very favourable throughout the entire season and dry matter harvests were conducted in mid-June and mid-July.

Early corn growth (mid-June) at the Lucan site was unaffected by the tillage treatments regardless of whether the previous crop was corn or soybeans. Although the moldboard (dry) treatment resulted in the highest corn growth following both of these crops the differences were not statistically significant (Table 9). In mid-July differences in accumulated dry matter among the various tillage systems were not significant following either corn or soybeans.

Corn grain yields were unusually low at Comber and exceptionally high at Lucan. Precipitation (or lack of it) exerts far more influence than the treatments themselves. There were no significant differences in grain corn yield among any of the tillage treatments at the Lucan sites (Table 10).

At Comber grain yield differences among treatments were significant following both previous crops. Following corn, 2 of the top 3 yielding treatments were moldboard plow (wet and dry). Following soybeans there were no significant differences among the 8 highest

yielding treatments. Yields tended to be lowest following chisel plowing with sweeps.

Regardless of the implement, soil moisture content at the time of fall tillage appeared to have no effect on grain yield of corn in 1991.

Corn yields achieved by spring cultivation only was on average (over both sites) 6% less than moldboard (dry) yields when the previous crop was corn. However, following soybeans spring cultivation outyielded moldboard (dry) by 1% when averaged over both sites. These differences, as indicated earlier, were generally not significant but indicate the degree of success achieved by this tillage option especially when soybeans preceded corn in rotation.

Table 9. The effect of tillage systems on corn dry matter accumulation at Lucan in 1991.

Tillage System	Previous Crop: / Harvest Date:	Corn June 13	Corn July 15	Soybeans June 11	Soybeans July 19
		———— kg ha^{-1}			————
Spring cultivate only		340	5770	412	7810
Offset disc (wet)		465	6560	405	8090
Offset disc (dry)		363	6380	407	8290
Chisel, sweep (wet)		429	5930	439	7190
Chisel, sweep (dry)		364	5130	390	7830
Chisel, shovel, 12 cm (wet)		312	5540	383	7490
Chisel, shovel, 12 cm (dry)		383	5980	435	7650
Chisel, shovel, 18 cm (wet)		426	5720	384	7310
Chisel, shovel, 18 cm (dry)		435	5710	436	7520
Moldboard (wet)		448	5640	439	8170
Moldboard (dry)		533	6190	491	7730
Average (wet)		416	5880	410	7650
Average dry		416	5880	432	7800
LSD (0.05)		NS	NS	NS	NS

Table 10. The effect of tillage systems on grain corn yields at Comber and Lucan.

Tillage System	Location: Previous Crop:	Comber Corn	Comber Soybeans	Lucan Corn	Lucan Soybeans
		------- kg ha^{-1} (15.5% moisture) -------			
Spring cultivate only		3700	4450	10,340	11,290
Offset disc (wet)		3420	4010	10,910	10,610
Offset disc (dry)		3650	3800	10,810	11,070
Chisel, sweeps (wet)		2620	3840	10,410	11,160
Chisel, sweeps (dry)		3510	3510	9,940	11,670
Chisel, shovel, 12 cm (wet)		3560	4330	9,920	10,820
Chisel, shovel, 12 cm (dry)		3060	4170	10,290	10,970
Chisel, shovel, 18 cm (wet)		3640	4080	9,560	11,220
Chisel, shovel, 18 cm (dry)		3140	3950	10,970	10,890
Chisel, shovel, 18 cm (dry) + early secondary tillage		4010	4320	10,320	11,330
Chisel, shovel, 18 cm (dry) + levelling harrow		4380	4160	10,440	11,250
Chisel, shovel, 18 cm dry + levelling harrow + early 2 tillage		3570	4740	11,140	11,410
Moldboard (wet)		4600	4160	10,820	10,860
Moldboard (dry)		4050	4420	10,650	11,260
LSD (0.05)		823	610	NS	NS

CONCLUSIONS

It is impossible to draw definitive conclusions for research that spans only a single growing season. The extreme weather conditions experienced in 1991 make conclusions even more tentative. However, in terms of the original objectives for this project we make the following observations.

Soil physical properties and crop response were not affected by soil moisture contents at the time of fall tillage when the range between "wet" and "dry" conditions was 2-5% (gravimetric soil moisture). No particular mulch implement appeared to be less suited than

others to working in wetter soil conditions.

Harrowing or levelling operations in the fall following chisel plowing and performing secondary tillage earlier in the spring may effectively reduce soil drying rates. However, those practices will probably have a noticeable impact on seedbed conditions only in springs where there are significant and prolonged early spring drying trends.

Results of this study add to our information base regarding mulch tillage systems for corn production. In general, mulch tillage systems are more suited to corn production in terms of soil conditions and corn yield when soybeans rather than corn is the previous crop. However, following soybeans, nearly all mulch tillage systems reduce residue cover to levels where significant protection from soil erosion will not be provided. Our recommendations based on this study would be to perform no fall tillage operations following soybeans and to limit tillage in the spring to a minimum.

Following corn, most mulch tillage operations provided adequate soil residue cover but, produce soil physical conditions (coarser seedbeds, greater soil strengths) inferior to those obtained by moldboard plowing. Generally this did not result in lower corn yields on the silt loam soil but on the clay loam soil mulch systems tended to result in corn yields lower than those obtained by moldboard tillage.

These investigations need to be repeated to overcome some of the farmer reluctance to switch from fall moldboard plowing, particularly on fine-textured soils during wet falls and to promote the reduction of tillage when soybeans are the previous crop.

EXTENSION ACTIVITIES

Results from this study have made up all or part of the following presentations which have been given since the beginning of the study or are scheduled for the future.

Crop Rotations, Modified Tillage Systems and their Effect on Soybean Production. Southwestern Ontario Farmers Week. January, 1992. Ridgetown, Ontario.

Planter Modifications For Zero Tillage. Bluewater Conservation Club Information Meeting. February, 1992. Petrolia, Ontario.

Tillage and Fertility in Ontario. Ontario Corn Producers Annual Meeting. February, 1992. London, Ontario.

Management of Mulch Tillage Systems on Clay Soils. Innovative Farmers No-Till Workshop. March 3 and 4, 1992. London, Ontario.

Reduced Tillage for Corn and Soybeans. Ball Farm Services Information Day. April, 1992. Aylmer, Ontario.

Reduced Tillage for Corn and Soybeans. Bluewater Conservation Club Information Meeting. April, 1992. Petrolia, Ontario.

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